ICT Trends in Education

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Introduction

The use of information and communications technology (ICT) in education is a relatively new phenomenon. Educators, researchers and thinkers have taken up the challenges of using ICT since the 1980s with varied success. The advent of the internet and the World Wide Web has pressured new productivity and service demands as well as expectations on these endeavours although research to guide best practice remains scant and elusive.

This discussion about the trends occurring in ICT in education and research begins with a brief history. The brief history of ICT raises a number of issues that provide options for thinking about the future and the pathways that ICT may take in an education context.

A brief history

The internet of today was born in 1973 when Vint Cerf developed the TCP/IP protocol. Not only could files be transferred quite simply but also information could be posted for public perusal leading to the emergence of email and news services. The introduction of computers as personal productivity devices first began to appear around 1977 with Apple, Tandy and Commodore computers. Although computers could be connected in networks for the purposes of transferring files although such operations remained complex and technically demanding.

In 1989 Robert Cailliau (Gillies, J. & Cailliau, R., 2001) and Tim Berners-Lee at CERN in Switzerland put forward a proposal for the management of documents using computers. Management at CERN received the proposal as ‘vague but exciting (Gillies, 2001, p. 181). Cailliau and Berners-Lee envisaged a service that could share files, documents, information, dialogue, graphics, sound files and more. They called this service the World Wide Web (WWW). Networking using the WWW continued frenetically until in 2001 the dot com crash rationalised the services that could be provided and consolidated the first round of the WWW for the provision of information globally.

Throughout this entire period, a computer and desktop software needed to be purchased and software installed. The software included an operating system, applications and utilities for checking viruses and the like. When computers were connected they then required additional software and network servers to communicate on the internet and use the WWW services.

The initial stages of the WWW from 1990 to 2001 provided the capacity for an information service. Schools, training colleges and universities developed websites as part of the proliferation of information accessible globally. The websites were institutionally focussed and somewhat akin to reading manuals. This meant that access by users was limited to the provision of information only in text formats with littleconsideration for being user friendly or user focussed. This was described in a predictions about the internet in 1999 called *The ClueTrain Manifesto* (Levine et al, 2000) as a passive ‘push’ model of communication.*The Cluetrain Manifesto* predicted

that users of the internet would become more actively involved in a networked ‘pull’ environment.

Then beginning in 2001, other types of services began to appear on the WWW. These included *Google, Wikipedia, MySpace, FaceBook, Digg, Technorati, Twitter, Spock* and many more which provided their services remotely and freely. These services are known as Software as a Service (SaaS) applications and remove the need for common desktop productivity software of the kind *Word, Excel, PowerPoint* and the like.

The WWW had moved towards becoming a read/write platform where users could engage with others, contribute and publish information in several formats including text, graphics, animation, audio and video. Tim O’Rielly (2005) popularised this new use of the WWW as Web 2.0, a term that became widely accepted although the term had been used several years previously. The term did not mean that the WWW underwent a technical change but instead became a platform where interactive communication was possible. In the ClueTrain Manifesto this was described s the ‘pull’ model of communication.

The combined internet and the WWW has matured as a communications, productivity and social networking platform in its own right with no precedent in history. Professor Jim Bosco (2006) from Western Michigan University has traced the development of communication through history and highlights the development of human communications through verbal, written and now electronic communication. He concludes by suggesting that today we are in a period where verbal and written communication operate electronically, globally and more personally than ever before and that has profound implications for education, business and research. Bosco (2006, p. 8) also states that the hegemony of formal education - school - as the educational agency for society - has ended because the available capacity for personalisation and individual contribution will be increasingly used by a diverse range of groups for education.

In examining the brief history above, a number of issues emerged. The computer has become a productivity and communication networking device beyond use as a stand alone machine which it was when personal computers began. The new trend towards SaaS services from remote central locations does not require the purchase and installation of desktop software productivity applications but does require access to the internet. Mention has also been made of changes which need to be further explored in education, research and business with the impact of personalisation and the ‘pull’ versus ‘push’ expectations of experienced and connected online users.

Purpose

The purpose of this paper is to develop a research based paper describing:

- the trends occurring in ICT in education
- the roles of ICT in education in Australia
- an indication of areas for research and associated services and
- an indication of long term theories about use of ICT in education to inspire future research.

A brief background below begins the discussion.

Background

A brief examination of some aspects of the Australian context in which ICT is being used in education is useful to begin. Two aspects have been outlined below: the take up of ICT in Australia and a scan of current national policy in relation to ICT in education in Australia.

Australian ICT take up

The *Australian Internet Activity Report* from ABS[1] (2008) reports that in December, 2007, there were 7.10 million subscribers to the internet in Australia of which 6.14 million were household subscribers. Non-dial up subscribers represent 73% of internet subscribers which show an increase of 33% since September, 2006. Most non-dial up subscribers (73%) use DSL[2] services which are dominant although wireless and satellite subscribers continue to increase. This information confirms that broadband access to the internet has become mainstream in Australia.

The take up of ICT in education in Australia is strongly dependent on the provision of reception infrastructure, that is, the provision of computers and networking as well as the professional development of teachers. MCEETYA (2004) reports on the provision of computers to schools:

> Some jurisdictions have achieved their targets of providing at least one computer for every five students and some are trialling other forms of technology including interactive digital whiteboards and personal digital assistants. (MCEETYA, 2004).

Ainley (2007, p. 20) cites the PISA 2003 study with results indicating that in Australia there is an average ratio of 3.3 computers per student at school. However, 93% of students indicate that they have a computer at home, with 83% indicating a link to the internet and 67% using educational software. Networking in schools is not as advanced with MCEETYA (2004) reporting that:

> In 2004 within the government sector, significant progress in the provision of bandwidth was made. Over 40 per cent of schools had access to a service with a bandwidth of at least 1 megabyte capacity. This was a significant improvement from 2002 when less than 10 per cent of schools had access to such a service. However, many schools do not yet have adequate access with nearly half of all schools still using services of 256 kilobytes or less in 2004.

This situation has improved since 2004 with major networking initiatives to connect schools to the internet and improve internal school networks in many Australian states. This will improve further with the Australian Government, announcing in early 2008 a substantial policy in education called the *Digital Education Revolution*.

What is the Digital Education Revolution?

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[1] ABS is the Australian Bureau of Statistics which can be accessed at: http://www.abs.gov.au.
[2] DSL is Digital Subscriber Line which is a service that uses the existing telephone network.

The *Digital Education Revolution* (DER) policy is focussed on the provision of computers for secondary students in Years 9 – 12; with high speed broadband connections to Australian schools. In addition, the policy will support the continued development of online curriculum content, conferencing facilities, pre-service and in-service professional development for teachers and the development of web portals to enable community participation in education. The DER will operate over a period of four years and educators can expect significant changes in education to occur as a wider group become engaged in the education process.

The provision of computers to students and connections to the internet will have a series of consequences that will impact the transformation of schooling. In their recent Communiqué (MCEETYA, 2008), Ministers:

> … noted that widespread access to, and effective use of, ICT in Australia's education and training sectors has the capacity to create opportunities to transform learning and teaching environments that can improve education outcomes and increase social and economic participation across Australia.
>
> (MCEETYA, 2008, p. 1))

The implication in this statement is that Ministers will begin to examine learning and teaching environments that transform learning to achieve improved outcomes, and social and economic participation. This may give rise to research into areas of educational use of ICT such as pedagogy, social networking, identity and learning portfolios (eportfolios), student management and assessment. A global search for innovative and effective world class learning environments that utilises ICT in education and training, and creative thinking about how to maximise learning based on research may be a good starting point.

Given the brief introduction to the role and functions of ACER, the take-up of ICT and current national policy in ICT in education, what are the trends in ICT in education?

ICT trends

In discussing the trends in ICT in Australia, it is almost impossible not to focus globally because of the reach of the internet and its services like the WWW. The development of the social web and its many variations such as relational networking, personal networking and social networking all have communications in common. The early iterations and services provided by the web were largely content and information centric. In fact, one of the features of the WWW was an information overload which spurred the development of search engines leading to services that enabled information to be discovered more quickly and easily.

Some examples of different types of search engines include *Google* and *Live* (search), *Yahoo* (browse), *Dogpile* (meta-search), *Spock* (people), *Google Scholar* and *Live Search Academic* (research), and *DMOZ Open Search Directory* and *Ask Jeeves* (human-edited). A fuller list of search engines in a variety of categories can be found on services such as *Wikipedia* and *Search Engine Watch*. The power of search engines to access information has lead to quick and easy information retrieval on almost any topic and, with the right skills, relevant, authoritative and accurate information can be gained.

A number of national ICT bodies between 2003 and 2008 have reviewed the trends in ICT in education as part of their monitoring of emerging technologies. They include bodies such as the *British Education and Communications Agency* (BECTa), *Education.au Limited* (Australia) and the *US Consortium of School Networks* (CoSN) as well as *EDUCAUSE* and the *New Media Consortium* (NMC) in the US who have compiled the 2007 and 2008 *Horizons* reports. However, in reviewing trends in ICT there is a need to consider Zittrain's (2008) comments when he says, '… people's experiences with the Internet (sic) are shaped at least as much by the devices they use to access it.' (Zittrain, 2008, p. 8).

Reports by CoSN, BECTa and Education.au Limited have primarily focussed on devices to access the internet and services provided on the internet that are emerging. Such a list would include personal digital devices or devices such as mobile phones, MP3 players, laptop computers, tablet PCs, games devices, scanners, interactive whiteboards, digital cameras and videos, RFID and digital TVs. The affordances enabled by these devices and web based services need also to be considered. They could include podcasts, vodcasts, peer-to-peer networking, content syndication, blogs and moblogs, photoblogs, wikis, tag clouds, smart cards and voice over IP. In addition, there have been a number of education packages released on the market that have influenced the take up of ICT in education. These packages may include learning and content management systems, web conferencing, slide sharing, student report cards, eportfolios, virtual classrooms, plagiarism detection, virtual worlds and online collaborative work spaces.

However, the following issues that will be discussed are those that will have a major impact on education and training in future years and include open source software and open content, social networking, collaboration and sharing, mobile technologies, new scholarship and peer to peer technologies.

Open source & open education resources

The open source movement began with Richard Stallman who founded the GNU Project to develop a free operating system in 1983 and went on to initiate the Free Software Foundation. in 1985. Then at the University of Helsinki, in 1996, Linus Torvalds presented the Linux Operating System as part of a thesis. Torvalds (1996) work is now embodied in the *Open Source Initiative* (2008) and is about open source software. Open source software is described on the site as a development method for software that harnesses the power of distributed peer review and transparency of process. The promise of open source is better quality, higher reliability, more flexibility, lower cost, and an end to predatory vendor lock-in (OSI, 2008). This initiative culminated in open source software where the user could modify the kernel of the code but had an obligation to contribute that modification back to the open source community.

The development of an open source operating system by Torvalds (1996) spurred the development of open content that users could access free of charge, especially for educational purposes. Some excellent examples are the *Open Educational Resources* (OER) Project which has become the *OER Commons* (2008) and *Curriki* (2008) both of which provide educational content for schools. However, the most accessed content service in education on the WWW is *Wikipedia* (2008) which is a good place to begin

searching a topic, although users need the skills to determine the currency, relevancy and accuracy of items. These three projects are examples of collective intelligence being utilised to develop large collections of information for public global access. Many open projects have been enhanced by the development by Laurence Lessig from Stanford University of a public access, copyright-free regime for trusted internet users called the Creative Commons.

The influence of the open source movement continues to make an impact on education because of the reduced costs of installation and maintenance of a compendium of office productivity applications and access to free content and services specifically dedicated to education. Open source software can avoid the issue of vendor 'lock-in' where users become constrained by a commercial product. Although open source software, services and content have matured there remains unfounded uncertainty about the robustness and reliability of these applications in education as a viable option to be considered, dependent on the uses for which services may be deployed (Hudson, 2004). Support for open source software and applications occurs via social networking services that result in quick responses to each innovation and new iteration.

Social networking

Social networking has been variously described as Web 2.0 technologies, relational technologies and interactive personal networking (IPN). Both social networking and IPN are descriptive terms reflecting the technologies whereas Web 2.0 popularised by O'Reilly (2005) is a marketing term while other terms such as relational networking, introduced by Joel de Resnais (2005), nominate a slew of activity such as dating sites and chat rooms only. However, Web 2.0 has become the term that is commonly used to identify IPN. What then is Web 2.0? In the succinct words of John Seely Brown a clear distinction between Web 1.0 and Web 2.0 was made when he stated:

> The original World Wide Web—the "Web 1.0" that emerged in the mid-1990s—vastly expanded access to information. The Open Educational Resources movement is an example of the impact that the Web 1.0 has had on education. But the Web 2.0, which has emerged in just the past few years, is sparking an even more far-reaching revolution. Tools such as blogs, wikis, social networks, tagging systems, mashups, and content-sharing sites are examples of a new user-centric information infrastructure that emphasizes participation (e.g., creating, re-mixing) over presentation, that encourages focused conversation and short briefs (often written in a less technical, public vernacular) rather than traditional publication, and that facilitates innovative explorations, experimentations, and purposeful tinkerings that often form the basis of a situated understanding emerging from action, not passivity.
>
> (Brown, J., 2008).

The clear difference between the passive information web and the interactive communication web articulated by Brown and predicted in *The ClueTrain Manifesto* as far back as 1999, has been described and is known as the read/write (Gillmor, 2004) web. The read/write web is a new platform with no precedent where sharing and publishing documents and multi media items have become common. The effect of Web 2.0 on education is already the focus for researchers such as Danah Boyd (2008) and institutions such as the Social Computing Lab at the Rochester Institute of Technology. As Web 2.0 becomes more commonplace in education demand for such research will intensify.

Social networking or Web 2.0 sites such as *MySpace*, *Facebook*, *Flickr*, *YouTube* and *Twitter* have reached wide acceptance and high user access. These services are about networking and sharing, that is, in the first instance they are about concepts and objects. However, the future of Web 2.0 is moving towards social operating systems which will focus on relationships and connections instead of concepts and objects (NMC, 2008, p. 26). As well as engaging with networks of like minded individuals or communities of interest, users will also be able to gain a map of publications, networks, writings, photos, blog comments and more about an individual. Some examples of social operating systems include *Yahoo Life!* and *Xobni*. The social networks and then social operating systems will lead to electronic profiling and network credibility for learners, scholars, researchers and teachers.

The new Web 2.0 platform will also offer for educational use a host of unique tools such as *Google Maps*, *Google Earth*, and *Zotero* (bibliography tool), office productivity suites such as *Google Apps*, *Zoho* and *EyeOS* as well as tagging of content and services such as folksonomies as opposed to metadata for search and retrieval. The impact of folksonomies may be the localisation of searching the WWW using common cultural or folk terms such as a 'cloud of tags' that will become an alternative to the currently accepted metadata standards.

The new WWW platform of Web 2.0 has also spurred advancement of new global and publicly accessible publishing tools. That is, Web 2.0 has provided a global platform for universal publishing without the intervention of editors, publishers and production facilities which have become increasingly more expensive. In fact, the new blogging and wiki capacities of the WWW have complemented print publishing by driving up print activity according to the Australian printing industry association *Print21online* (Print21, 2008) which states, 'Instead of spelling a death to printing, the act of blogging is in fact driving print sales'. However, overall the print industry would appear to be in slow decline according to ABS data cited in *Print21online* (2008) which stated that:

> The printing industry continues to be in recession according to the December 2007 quarter national accounts figures released today by the Australian Bureau of Statistics (ABS). The December quarter data shows that the printing, publishing and recorded media industry declined by 1.7 per cent during the quarter on trend basis resulting in an annual decline of 2.1 per cent. (Print 21, 2008)

However, from the same source (Print21, 2008) we also read that from the period of July-September 2007, the Sydney Morning Herald online attracted nearly four million unique browsers compared to the newspaper, which had circulation figures of 211, 700. The figures would seem to suggest that the print industry is interwoven, almost dependent, on the online services including blogging. Online services are also being used to manage and edit other publications such as academic journals.

A number of leading educational researchers and authors have deferred to the use of Web 2.0 tools to publish and receive feedback on their work and the work of others through iterative and interactive methods. The result has been that the new Web 2.0 media has enabled researchers to lead communities in notifying research and evidence, provoke debate and discussion, and advance the work of communities of

practice which have opened up new vistas for researchers. The days of researchers working individually and not connected to other like minded researchers may be limited as collaborative affordances increase.

A recent announcement by the Harvard Law School (2008) to provide open access to scholarly articles is a move towards an open access policy at Harvard. It precedes a Bill before the US Congress that may mandate that all federally funded research be available in open access that could encourage online collaboration among researchers.

Collaboration

Web 2.0 tools such as *Google Apps* and *Zoho Office*, mentioned previously, enable people to collaboratively write documents, construct presentations, develop budgets and build stories and research; that is share and work together to build content. In addition, Web 2.0 can enable people to work in collaborative workspaces over distance, to share resources and capture ideas. The results whether they be documents, photos, videos, slideshows, presentations, data, audio narrations or other rich media can then be stored on the WWW for access globally or in a closed community. These technologies can be used without the need to buy or install software and have lead to the development of collaborative network spaces such as *Ning*, *Facebook*, *Pageflakes*, *Netvibes* and the like. An excellent example of collaborative networking that has saved both time and money is the use of a wiki to manage and develop the ALC[3] project at ACER.

Collaboration using Web 2.0 is rigorous, demanding and exacting. It has given rise to leadership using the WWW by academics, researchers and business leaders many of whom have gained global credibility and a large following by their regular, relevant and accurate publishing. Conceptually these leaders have had their ideas appended, amended and refined through interactive feedback by contributors to their community of practice and their research has benefited and become richer. One such theory that has been developed through interactive collaboration is the theory of connected learning called ‘connectivism’ put forward by George Siemens (2007) and debated globally. This theory has been widely discussed and refined over a number of years by contributors to Siemens’ blog and has been demonstrated in the publication *Knowing knowledge* (Siemens, 2008) which has been published online where it is accessible globally.

The theory of connected learning or ‘connectivism’ has become widely accepted in education and has built on the work of The *Wisdom of the Crowds* (Surowiecki, 2005), which is about collective intelligence and distributed leadership in education (Gunter, 2005) and collaboration (Rheingold, 2001; Rosen , 2007; Elliott, 2008). However, challenges lay ahead as the renewed emphasis for collaborative learning gains momentum. As stated by NMC (2008, p. 5) collaborative learning is pushing the educational community to develop new forms of interaction and assessment. However, as cited in Fluck (2008, P. 158) the NAEP[4] concluded that testing students in technology-rich environments is important in order to ‘measure skills that cannot be easily measured by conventional paper-and pencil means’, for example, computer based searches, simulations and certain problem solving in science.

[3] ALC is the Assessment of Language Competence service at ACER.
[4] NAEP is the National Assessment of Educational Progress in the USA.

Other technologies which are widely used and that assist collaboration include peer-to-peer technologies such as *Skype* (communication) and *Bit Torrent* (sharing content). These technologies are very difficult to control and are open to intervention posing security threats when used on an organisational basis as opposed to being used personally from a home account. Peer-to-peer technologies have been regarded legally as circumvention technologies (viz. *Kazaa*) although they are powerful and efficient, and used as the background for grid computing in scientific research where large scale computing power is required. Another area of collaborative activity can be seen in virtual worlds such as *Second Life* where engaging learners in simulations can be a powerful educational learning environment tool. Mobile phones are also included in the overall discussion of collaboration but their impact on education is uncertain?

Mobile technologies

The use of mobile communication has increased exponentially in the last decade. In Australia, ACMA[5] (2008, p. 25) report that there are more users of mobile-cell phones, referred to as mobile phones, than fix line users. Numerous reports alert readers to the impending impact on education of mobile technologies (CoSN, 2004; Education.au Limited, 2005; BECTa, 2006; NMC, 2007; NMC, 2008). Each makes the point that mobile phones are evidence of the convergence of digital technology and that they are expected to make a significant impact on education and learning, especially through the use of games.

There is not sufficient evidence to suggest that mobile phones will make such an impact on education. Two reasons for this are proposed. Firstly, mobile phones are connected devices of convenience, that is, they are used for communicating, messaging, quick information access such as the time and weather, and for personal organisation as well as entertainment including games. On the other hand, computers are used as connected productivity devices that utilise communication and information. Secondly, recently released onto the market are low cost portable computing devices such as the ASUS EEE PC, Intel Classmate, Everex, HP and many more spurred on by the MIT, *One Laptop per Child* (OLPC) project, and the release to governments of their XO computer.

These sub-laptop robust devices are custom made for the education market and as productivity tools they have appropriately sized keyboards and screens, and are less complex to use for productivity and collaboration than mobile phones which need to offer productivity compromises such as predictive text instead of a keyboard. In addition, mobile phones lack connectivity such as adapters and ports with the result that their productivity potential will remain limited into the foreseeable future and they will remain devices of convenience, personal organisation and entertainment.

However, as devices of convenience and personal organisation, they can be useful in education for a number of organisational functions such as notifying absences, timetables, reminders, deadlines, tracking of library loans using RFID[6], games and

[5] ACMA is the Australian Communications and Media Authority.
[6] RFID is Radio Frequency Identification and is a technology similar in theory to bar code identification.

more. As argued above these functions are mainly related to personal organisation and entertainment rather than productivity. Research into the use of the mobile phones would appear to be limited to personal management and convenience more relative to the persuasion of market forces than to research, learning, teaching or education. Watson (2006) provides a comprehensive discussion about the use of mobile technologies in education which highlights the experimental nature of work so far.

A number of exceptions to the above augment are beginning to appear in case studies of learning where mobile phones have been used successfully for language learning and listening to lectures and speeches using podcasts to mobile phones. The release on the market of video capable mobile phones such as the Apple iphone may also realise more experimentation and trials of mobile phones in learning. However, considerably more experimentation, trailing and research is needed on the use of mobile phones in learning before confident statements about their benefits can be made, although it should be noted that the mobile phone is one device that is almost ubiquitous among secondary school students. The use of convergent mobile technologies in education to enhance and modify learning is in its early stages which leads to a discussion about scholarship.

Scholarship

Changes in the way that the WWW operates have brought about a wider array of choices for scholars in undertaking research, writing, reviews and collaboration. There is little debate that searching scholarly databases has been made easier through web based searches where access has been permitted. One important example, is inthe changes that have been made in universities by librarians who have enabled global searches of journals, publications and articles for their staff and students. Two recent SaaS additions, in the public arena providing search for scholarly publications have included *Google Scholar* and *Google Books*. These SaaS services have not only improved access to scholarly publications for researchers but also for the general population.

Finding and gathering information using ICT has enabled faster access to resources and cost and time savings for researchers. This can be illustrated by the extensive use of *SPSS*[7] (quantitative) and *NVivo* (qualitative) as well as online survey tools such as *Survey Monkey*, *Lime Survey*[8] and *Zoomerang* for online surveys and online polling.

Science is a field in which researchers have a long history of collaboration which can be seen in the way that they build on each other's work. ICT has helped to further the collaboration between scientists through obvious technologies such as email and websites. However, the recent development of SaaS services has also enabled document sharing. An example of document sharing can be seen with the application of *Google docs* in which several editors can edit the same document in real time. When the document has been completed the authors may wish to send it to a journal for review and publication. The possibility that the editor of the journal uses an

[7] SPSS is a software program Statistical Package for the Social Sciences.
[8] Indicated by ACER, IT section.

automated system such as *Open Journal Systems* for journal management and publishing is quite realistic[9].

In fact, the whole area of publishing on the internet has changed with the arrival of SaaS services. A number of communities have developed around academic researchers and authors who publish regularly on the WWW using blogs. These communities can be closed to a specific group of people or open to all comers on a global scale. Two examples of such communities are Stephen's Web which is the work of Stephen Downes, a researcher with the Canadian National Research Council who developed E-Learning 2.0 (Downes, 2005) and *elearnspace* by George Siemens (2008) who developed the learning theory for the digital age known as connectivism. Both Downes and Siemens are regarded as world leaders in their respective fields aided by the affordances of SaaS services.

The above examples illustrate how the interactive WWW has changed the possibilities for engaging in scholarship, academic leadership and research through sharing, collaborating and publishing. However, there remain a number of issues yet to resolve and two are mentioned here: plagiarism and peer review. In an age when electronic systems enable cutting and pasting of text and graphics as well as sharing and collaboration, there needs to be further work, agreements and protocols on how to handle these issues. Although a start has been made with systems for detecting plagiarism with software such as *Turnitin* such programs can only be a supplement to the accepted values of rigorous and robust scholarship.

Other issues such as digital copyright, intellectual property, safety (infections) and security (privacy) are areas that could affect scholarship using ICT and about which progress continues to be made. That said, change continues unabated. In fact, The *Horizons Report 2008* (NMC, 2008) includes in its discussion about significant trends the statement:

> The growing use of Web 2.0 and social networking- combined with collective intelligence and mass amateurization-is gradually but inexorably changing the practice of scholarship. Horizons Report, 2008, p. 4)

The *2007 Horizons Report* also noted scholarship, research, creative expression and learning (Horizons, 2007. p. 4) as areas considered to be critical challenges for higher education in the years ahead. However, of more significance for academics and researchers about the future of the internet is its lack of structure to manage personal identity and its inability to guarantee transmission speed between two points. (Zittrain, 2008. p. 32). *Horizons* (2008) identified scholarship as a critical challenge for the future when it stated:

> Significant shifts in scholarship, research, creative expression, and learning have created a need for innovation and leadership at all levels of the academy (Horizons, 2008. p. 5).

The research on innovation and leadership in education is strong and if ICT is transformational in scholarship, research and education then there is a need to

[9] Indicated by Professor Stephen Dinham.

understand and learn from the research in these areas. If this is the case then what are the roles of ICT in education?

ICT roles in Australia

Over a decade ago, discussion would have centred on the role of the computer at a time when stand-alone computers, that is, not connected computers, were being introduced into schools. Simple descriptions utilising methodological elements prevailed such as computers used for simulations, drill and practice, electronic whiteboards, tutorials, retrieval, games, and so on. However, two theories, by Taylor (1980) and Rushby (1984), on the role of computers at that time stand out. Briefly reviewing their propositions on the roles of computers as stand alone devices is useful because some of those roles remain relevant for computers in a connected world today.

The role of computers advanced by Taylor (1982) suggested that computers in education could be seen as ‘tools’, ‘tutors’, or ‘tutees. The tool role has been associated with productivity, the tutor role was often linked to multiple choice type exercises and the tutee role to instructed learners. However, it is the role of the computer as a tool, which is somewhat limiting, that is more often described today even though learning objects utilise the tutor role and simulations utilise the tutee role.

One of the more powerful concepts developed prior to the WWW about the role of the computer in education was developed by Rushby (1984). Rushby put forward four different paradigms which he called instructional, revelatory, conjectural and emancipatory. The instructional paradigm was about student learning from computers, the revelatory about building ideas from information, the conjectural about testing ideas and modelling data, and the emancipatory reduced workload. These four different uses of computers remain useful to this day even though they were developed when computers were not connected using the WWW.

Since the 1990’s, as educational use of computers using the WWW has gained momentum, there have been numerous attempts to describe the role of ICT, many focussed on the devices themselves and others examining the functions that users perform when using ICT. Two works in Australia are worth noting; the first by Spring (2004) and the second by Lonsdale (2003).

Spring (2004) toured Australia far and wide discussing ICT in education with students, teachers, communities and educational administrators. Spring summarised what was described as the five teaching and learning modes in which elearning could provide substantial gains in effectiveness, quality and cost benefits (p. 37). They were:

- **Classroom interactive learning** between students and teachers and among students.
- **Independent learning** where students or teachers are learning and studying alone in a variety of environments and modes including aspects of self directed lifelong learning.

- **Networked learning** through contact with groups, individuals and sources where quite different influences and experiences are creating a qualitative difference to both standard and blended teaching and learning.
- **Organisational learning** including learning communities, learning precincts and learning cities.
- **Managed learning** where education technology is creating, through computer managed communication and learning management systems, capability to enable teachers to negotiate and provide individualised curricula and learning experiences for each student.

(Spring, G. 2004. p. 37).

This categorisation of elearning is inclusive of most of the ways that ICT can be used in education as it is currently organised. In another study, Lonsdale's (2003) classification focusses more on uses of the WWW and its users which were categorised for the first time.

Lonsdale (2003) examined the types of uses for which ICT was deployed in education broadly classifying them into four sub-groups: content, products, communication and site support. These sub groups were a classification of some 19 different types of uses of ICT portals. Lonsdale (2003) went further and categorised the users of WWW educational portals. The categories of users based on the types of use of ICT described in the *Global Gateways* report were searchers, explorers, self-improvers and participators.

The rise in the use of Web 2.0 services since 2003 has seen the emergence of users who also design, construct and modify ICT for group or personal use. This suggests that a fifth category of ICT users exist which is here described as 'customisers'. The five categories of ICT users in education that further research could test are:

- searchers
- explorers
- self-improvers
- participators, and
- customisers.

The roles that ICT play in the education scenario are inseparable from the types of uses that users employ ICT to perform. That is, an examination of users clarifies the roles of ICT in education today and ICT would appear to be especially suited to learning. More recently the computer has been described as a 'window not a destination' by technology strategist Marc Pesche (2008) in a keynote address at the Digital Education Revolution Workshop in Sydney. The role of ICT will continue to evolve but what about the capacity of people and institutions to adapt?

Long term future theories

The importance of ICT in education can not be under-estimated because of the way that ICT can be seen to be changing education and its transformative value. In fact, Pew Internet (2004) surveyed 1000 experts asking them how much change, on a 10 point scale, the internet will bring to institutions. The results placed education with a score of 7.98, second to news organisations and publishing with a score of 8.46. The internet is clearly expected to make significant changes to publishing, which has

already occurred, and to education. For this reason, a brief look at some of the long term theories about ICT that may impact education could be useful.

Two theories will be briefly mentioned. The first, a technical issue, from controversial author Nick Carr (2008) who postulates that the internet will move from a server/client model dependent on technical staff to a utility model of services supplied by remote SaaS vendors. He argues that although the security, efficiency and quality of service need to improve, the commoditisation of the internet/hardware/software enables users to control their own processing of information directly. Effectively, Carr is arguing that internet/WWW services will be provided externally and that users will manage their own use of the internet. There is some evidence that this may be occurring already through services such as *Google*, *Wikipedia*, *Zoho*, *Spock* and other SaaS services. If this does occur, in the same way that electricity supply moved to electricity grids and power stations instead of self generators, then the skills of using the internet/WWW will become critical to learning, education and the creation of knowledge. Research will be needed to determine the most effective skills necessary to engage in learning, education and development of knowledge in a connected world.

The second theory considered here is Kurzweil's (2001) interpretation of Venor Vinge's theory of singularity or the evolution of the brain as a result of rapid technological change. The Singularity, states Kurzweil (2001), is a technological change so rapid and so profound that it represents a rupture in the fabric of human history (p. 6). He argues that the evolution of intelligence will occur so rapidly that scientists will be able to think much more quickly because of greater intelligence and the development of new knowledge will take days instead of years. In fact, he suggests that the boundary between artificial intelligence and biological intelligence may become difficult to distinguish. If Kurzweil is even partially right then research into the effects of the use of ICT on thinking will become as important in education as in other realms of society.

However, Kurzweil's (2001) view is not currently widely accepted. Greenfield (2008) argues that quick and easy access to information is somewhat like a smorgasbord of information with the result that the meaning and depth of knowledge may be compromised because the capacity of the brain does not and will not change physiologically. In an interview with Times Online in April, 2008, Susan Greenfield sets out her view of the repercussions for youth of spending time online:

> … the substitution of virtual experience for real encounters; the impact of spoon-fed menu options as opposed to free-ranging inquiry; a decline in linguistic and visual imagination; an atrophy of creativity; contracted, brutalised text-messaging, lacking the verbs and conditional structures essential for complex thinking. Her principal concern is how computer games could be emphasising what she calls "process" over "content" – method over meaning – in mental activity. .
>
> For the mind to operate fully, Greenfield asserts, the prefrontal cortex must be active, and content must be a high priority. The world and oneself are then redolent with meaning. (Times Online, 2008)

Greenfield is arguing that learners are losing the capacity to use their brains effectively because of ICT and that the brain is not changing physiologically but has remained essentially the same for thousands of years although different parts of the

brain may dominate while others languish. If Greenfield is right then she adds weight to the urgency of undertaking research into the way that learners use the internet and WWW, so that it can be harnessed effectively for education because without research argues Greenfield (2008) there may be little understanding of the social, educational and cultural consequences.

Conclusion

ACMA's (2008) research clearly shows that change, connectivity and innovation are occurring at a rapid rate in Australia. It suggests that the current trends in ICT are:

- the accelerating pace of change
- diversity in the development of physical infrastructure
- the spread of distributed connectivity
- enhanced content and network management capabilities
- the emerging Social Web
- continuing scientific and technological innovation. ACMA, (2008)

These trends, stated by ACMA (2008), raise questions about the effects on learning and education that need to be explored carefully and thoroughly. The current national government policy on ICT adds emphasis to the need for research into the educational environment in which ICT is used, its effect on learning and possibly an exploration of diverse methods for delivering education and their effects on learning.

The internet and WWW have brought considerable change in capacity and globality for accessing and using information as well as communicating, both of which have impacted on education. The trends in ICT in education can be described by the devices that are used or by content or by the services that the internet and WWW provide. However, this paper has argued that a deeper analysis of ICT trends and impacts on learning and education is necessary to understand the trends in ICT in the context of education. The trends in the use of ICT in education that have been visited here together with their possible impacts on education and research include open source software and open education resources, social networking, collaboration, communications usage and user expectations, mobile technologies and scholarship. A pattern which is emerging is the richness of media that is available and diversity of processes that can be applied to those media for use in education and research. There is a need for research into the effects on learning and the capacity of education to explore these aspects of the use if ICT in education without which positive progress will be haphazard.

However, some theorists would argue that using ICT is affecting the evolution of and use of the human brain which is an issue that needs to be addressed if we are to understand the impact of ICT on learning and education. There are indeed many gaps in our knowledge about the uses of ICT in education many of which have been mentioned above. In order to address these issues a carefully programmed and resourced research agenda about ICT in education would appear to be essential. What are some of these areas of research?

Several areas for further research have been mentioned in this paper. There is a dearth of documentation in Australia on good practice implementing ICT in education in

large scale systems although some variable efforts, which could be instructive, have been made in the UK. At the school and classroom levels there is some documentation although access to such is difficult and time consuming. There is a need to analyse and celebrate successes and learn from failures to support the profession in this time of change through the publication of a diverse range of effective educational practices using ICT.

If Bosco (2006) is correct that the digital age has highlighted verbal communication as well as popular publishing then there exists scant information and research on the application of verbal communication in education in the digital age. The way that learners interact with each other has changed and the ways in which learners learn today needs renewed research efforts to complement the preceding rich research tradition about learning in an era of linear scientific methods and linear print protocols. This was as time when people often worked individually and did not have the capacity to be globally networked without considerable expense.

Although in the UK there is an education policy of personalisation, there has been little research to analyse the benefits and disadvantages of digital personalisation for learning. One of the recognised difficulties here is the development of learning programs where no real precedence is available. Perhaps there is a need for a reversal of the research and development tradition to development and research in order to gain knowledge from analysis and reflection about the use of ICT applied to personalisation of learning. In that way the more successful approaches and methods to using ICT in education could be realised and applied more widely.

As mentioned in the background of this paper, the new national policy of connectedness does suggest the need to examine learning and teaching environments and relevant issues such as pedagogy, social networking, creative and critical thinking, problem solving, identity and learning portfolios (eportfolios), student and course management, and assessment of student learning. A major question in education is how to maximise the uses of ICT in education taking into account that ICT is much more than a tool and provides a digital window to global access of information and to the capacity to interact in new ways in the creation of knowledge.

The spreading use of so called Web 2.0 ICT applications may well change the manner in which people connect and interact. Already we have terms such as co-presence (Ito, 2006) meaning always connected and ‘absent presence’ (Gergen, 2006) meaning otherwise engaged while in the company of people, emerging from studies of the uses of mobile technologies such as cell/mobile phones and handheld devices. These new patterns of interaction and communication will undoubtedly lead to cultural changes that education will need to understand and harness if learning opportunities are to be maximised.

Finally, the area of collaboration in education using ICT is one domain where research on the effects of collaboration in education is almost entirely absent. Ettienne Wenger (1999) coined the phrase communities of practice which today, using ICT, have become virtual communities and are widely used in education. However, researchers have been almost uniformly silent on the effects of collaboration on learning and the successes of virtual communities in learning. Much needs to be done to assist educators to understand the profound cultural and psychological changes that

are occurring and will occur in education as the take up of ICT in the digital age progresses.

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